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Modeling Capabilities of Digital Twin Platforms - Old Wine in New Bottles?

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Abstract: This extended abstract summarizes our paper [Pf22] on studying emerging modeling languages provided by digital twin platforms and contrasting them to established object-oriented modeling languages in the field of software engineering. This work has been originally published at the 18th European Conference on Modelling Foundations and Applications (proceedings are published in the Journal of Object Technology (JOT)) in 2022.

Keywords: Modeling Languages, Metamodeling, Digital Twins, Digital Twin Platforms

1 Summary

Digital twins are emerging in many domains to tackle the growing complexity of engineering and operating cyber-physical systems. However, the efficient development and maintenance of digital twins is an open challenge. Digital twin platforms aim to facilitate the engineering of digital twins by providing dedicated modeling languages and accompanying tools. With the emergence of these new languages, the question arises which concepts these languages provide and how they differentiate from modeling languages already used in software engineering since decades.

To better understand this emerging area, we studied the modeling capabilities of three industrial digital twin platforms. In particular, we present the conceptual metamodels of these three platforms, compare them with well-known object-oriented modeling languages, and provide first insights about the interoperability between these platforms, i.e., how to exchange models between them. This work can be seen as a starting point for uncovering the nature of digital twin modeling languages, for providing a family of digital twin modelling languages enabling developers to select appropriate modeling features for describing different aspects of digital twins, and for enabling interoperability between digital twins hosted on different platforms.

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In summary, we present the following three contributions:

- A structured discussion and comparison of the underlying modeling concepts of three selected DT platforms. To achieve this, we extracted conceptual metamodels from the modeling capabilities offered by the platforms.
- An estimation of the degree to which the metamodels provided by the respective platforms present novel concepts as well as a characterization of these languages based on their modeling concerns. For this, we aligned the extracted metamodels with existing, standardized object-oriented modeling concepts.
- An assessment of the compatibility of the identified concepts between different metamodels, using an UML extension as pivot for bridging the gap between standardized modeling concepts of UML and the metamodels provided by DT platforms.

The results of this work show that the modeling capabilities of the examined digital twin platforms rely on well-known object-oriented modeling techniques, but they also extend these general-purpose concepts with domain-specific features, such as quantities, units, flexible instantiation mechanisms to name just a few features. In addition, the languages use a wide spectrum of concrete notations and employ additional constraints which may result from performance considerations in the associated runtime environments.

2 Data Availability

The developed artefacts in the context of this work are available on Github (`https://github.com/derlehner/dt_language_comparison`).

Literatur

[Pf22] Pfeiffer, J.; Lehner, D.; Wortmann, A.; Wimmer, M.: Modeling Capabilities of Digital Twin Platforms - Old Wine in New Bottles? J. Object Technol. 21/3, 3:1–14, 2022, URL: https://doi.org/10.5381/jot.2022.21.3.a10.